

SECTION 33 40 00

STORM DRAINAGE UTILITIES
01/08

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACI INTERNATIONAL (ACI)

ACI 346 (2001) Specification for Cast-in-Place Concrete Pipe

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO HB-17 (2002; Errata 2003; Errata 2005) Standard Specifications for Highway Bridges

AASHTO M 167M/M 167 (2005) Corrugated Steel Structural Plate, Zinc-Coated, for Field-Bolted Pipe, Pipe-Arches and Arches

AASHTO M 190 (2004) Bituminous Coated Corrugated Metal Culvert Pipe and Pipe Arches

AASHTO M 198 (2005) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants

AASHTO M 219 (1992; R 2004) Corrugated Aluminum Alloy Structural Plate for Field-Bolted Pipe, Pipe-Arches, and Arches

AASHTO M 243 (1996; R 2004) Field-Applied Coating of Corrugated Metal Structural Plate for Pipe, Pipe-Arches, and Arches

AASHTO M 294 (2007) Standard Specification for Corrugated Polyethylene Pipe, 300- to 1200-mm Diameter

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION (AREMA)

AREMA Eng Man (2007) Manual for Railway Engineering

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M	(2002) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 48/A 48M	(2003) Standard Specification for Gray Iron Castings
ASTM A 536	(1984; R 2004) Standard Specification for Ductile Iron Castings
ASTM A 716	(2003) Standard Specification for Ductile Iron Culvert Pipe
ASTM A 74	(2006) Standard Specification for Cast Iron Soil Pipe and Fittings
ASTM A 742/A 742M	(2003) Standard Specification for Steel Sheet, Metallic Coated and Polymer Precoated for Corrugated Steel Pipe
ASTM A 760/A 760M	(2006) Standard Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains
ASTM A 762/A 762M	(2000) Standard Specification for Corrugated Steel Pipe, Polymer Precoated for Sewers and Drains
ASTM A 798/A 798M	(2001) Standard Practice for Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications
ASTM A 807/A 807M	(2002e1) Standard Practice for Installing Corrugated Steel Structural Plate Pipe for Sewers and Other Applications
ASTM A 849	(2000; R 2005) Standard Specification for Post-Applied Coatings, Pavings, and Linings for Corrugated Steel Sewer and Drainage Pipe
ASTM A 929/A 929M	(2001; R 2007) Standard Specification for Steel Sheet, Metallic-Coated by the Hot-Dip Process for Corrugated Steel Pipe
ASTM B 26/B 26M	(2005) Standard Specification for Aluminum-Alloy Sand Castings
ASTM B 745/B 745M	(1997; R 2005) Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains
ASTM C 1103	(2003) Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines

ASTM C 1103M	(2003) Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines (Metric)
ASTM C 12	(2007) Standard Practice for Installing Vitrified Clay Pipe Lines
ASTM C 139	(2005) Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes
ASTM C 14	(2007) Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe
ASTM C 1433	(2007) Standard Specification for Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers
ASTM C 1433M	(2007a) Standard Specification for Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers (Metric)
ASTM C 14M	(2005a) Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe (Metric)
ASTM C 231	(2004) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 270	(2007) Standard Specification for Mortar for Unit Masonry
ASTM C 32	(2005) Standard Specification for Sewer and Manhole Brick (Made from Clay or Shale)
ASTM C 425	(2004) Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings
ASTM C 443	(2005a) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C 443M	(2007) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets (Metric)
ASTM C 444	(2003) Perforated Concrete Pipe
ASTM C 444M	(2003) Perforated Concrete Pipe (Metric)
ASTM C 478	(2007) Standard Specification for Precast Reinforced Concrete Manhole Sections
ASTM C 478M	(2007) Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric)

ASTM C 506	(2007) Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe
ASTM C 506M	(2007) Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe (Metric)
ASTM C 507	(2007) Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe
ASTM C 507M	(2007) Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe (Metric)
ASTM C 55	(2006e1) Concrete Brick
ASTM C 564	(2003a) Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
ASTM C 62	(2005) Building Brick (Solid Masonry Units Made from Clay or Shale)
ASTM C 655	(2007) Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe
ASTM C 700	(2007e1) Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
ASTM C 76	(2007) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C 76M	(2007) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric)
ASTM C 828	(2006) Low-Pressure Air Test of Vitrified Clay Pipe Lines
ASTM C 877	(2002; E 2005) External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections
ASTM C 877M	(2002; E 2005) External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections (Metric)
ASTM C 923	(2007) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals
ASTM C 923M	(2007) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals (Metric)

ASTM C 924	(2002) Testing Concrete Pipe Sewer Lines by Low-Pressure Air Test Method
ASTM C 924M	(2002) Testing Concrete Pipe Sewer Liner by Low-Pressure Air Test Method (Metric)
ASTM D 1056	(2007) Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber
ASTM D 1171	(1999) Rubber Deterioration - Surface Ozone Cracking Outdoors or Chamber (Triangular Specimens)
ASTM D 1557	(2002e1) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft ³) (2700 kN-m/m ³)
ASTM D 1751	(2004) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D 1752	(2004a) Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion
ASTM D 1784	(2006a) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D 2167	(1994; R 2001) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D 2321	(2005) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D 2729	(2003) Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D 3034	(2006) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D 3212	(1996a; R 2003e1) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D 3350	(2006) Polyethylene Plastics Pipe and Fittings Materials
ASTM D 6938	(2007a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

ASTM F 1417	(1992; R 2005) Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low Pressure Air
ASTM F 477	(2007) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F 679	(2006a) Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings
ASTM F 714	(2006a) Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
ASTM F 794	(2003) Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter
ASTM F 894	(2007) Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe
ASTM F 949	(2006a) Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. The following shall be submitted in accordance with Section 01 33 23:

SD-03 Product Data

PVC pipe
Catch basin
Splitter box
Frames and grates

SD-06 Test Reports

Leakage tests; G
Deflection tests; G

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Delivery and Storage

Materials delivered to site shall be inspected for damage, unloaded, and stored with a minimum of handling. Materials shall not be stored directly on the ground. The inside of pipes and fittings shall be kept free of dirt and debris. Before, during, and after installation, plastic pipe and fittings shall be protected from any environment that would result in damage or deterioration to the material. The Contractor shall have a copy of the manufacturer's instructions available at the construction site at all times and shall follow these instructions unless directed otherwise by the

Contracting Officer. Solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install plastic pipe shall be stored in accordance with the manufacturer's recommendations and shall be discarded if the storage period exceeds the recommended shelf life. Solvents in use shall be discarded when the recommended pot life is exceeded.

1.4.2 Handling

Materials shall be handled in a manner that ensures delivery to the trench in sound, undamaged condition. Pipe shall be carried to the trench, not dragged.

PART 2 PRODUCTS

2.1 PIPE FOR CULVERTS AND STORM DRAINS

Pipe for culverts and storm drains shall be of the sizes indicated and shall conform to the requirements specified.

2.1.10 PVC Pipe

The pipe manufacturer's resin certification, indicating the cell classification of PVC used to manufacture the pipe, shall be submitted prior to installation of the pipe.

2.1.10.1 Type PSM PVC Pipe

ASTM D 3034, Type PSM, maximum SDR 35, produced from PVC certified by the compounder as meeting the requirements of ASTM D 1784, minimum cell class 12454-B.

2.1.10.2 Profile PVC Pipe

ASTM F 794, Series 46, produced from PVC certified by the compounder as meeting the requirements of ASTM D 1784, minimum cell class 12454-B.

2.1.10.3 Smooth Wall PVC Pipe

ASTM F 679 produced from PVC certified by the compounder as meeting the requirements of ASTM D 1784, minimum cell class 12454-B.

2.3 MISCELLANEOUS MATERIALS

2.3.1 Concrete

Unless otherwise specified, concrete and reinforced concrete shall conform to the requirements for 3000 psi concrete under Section 03 30 00 CAST-IN-PLACE CONCRETE. The concrete mixture shall have air content by volume of concrete, based on measurements made immediately after discharge from the mixer, of 5 to 7 percent when maximum size of coarse aggregate exceeds 37.5 mm(1-1/2 inches). Air content shall be determined in accordance with ASTM C 231. The concrete covering over steel reinforcing shall not be less than 25 mm(1 inch) thick for covers and not less than 40 mm(1-1/2 inches) thick for walls and flooring. Concrete covering deposited directly against the ground shall have a thickness of at least 75 mm(3 inches) between steel and ground. Expansion-joint filler material shall conform to ASTM D 1751, or

ASTM D 1752, or shall be resin-impregnated fiberboard conforming to the physical requirements of ASTM D 1752.

2.3.2 Mortar

Mortar for pipe joints, connections to other drainage structures, and brick or block construction shall conform to ASTM C 270, Type M, except that the maximum placement time shall be 1 hour. The quantity of water in the mixture shall be sufficient to produce a stiff workable. Water shall be clean and free of harmful acids, alkalies, and organic impurities. The mortar shall be used within 30 minutes after the ingredients are mixed with water. The inside of the joint shall be wiped clean and finished smooth. The mortar head on the outside shall be protected from air and sun with a proper covering until satisfactorily cured.

2.3.3 Precast Concrete Segmental Blocks

Precast concrete segmental block shall conform to ASTM C 139, not more than 200 mm(8 inches) thick, not less than 200 mm(8 inches) long, and of such shape that joints can be sealed effectively and bonded with cement mortar.

2.3.4 Brick

Brick shall conform to ASTM C 62, Grade SW; ASTM C 55, Grade S-I or S-II; or ASTM C 32, Grade MS. Mortar for jointing and plastering shall consist of one part portland cement and two parts fine sand. Lime may be added to the mortar in a quantity not more than 25 percent of the volume of cement. The joints shall be filled completely and shall be smooth and free from surplus mortar on the inside of the structure. Brick structures shall be plastered with 13 mm(1/2 inch) of mortar over the entire outside surface of the walls. For square or rectangular structures, brick shall be laid in stretcher courses with a header course every sixth course. For round structures, brick shall be laid radially with every sixth course a stretcher course.

2.3.5 Precast Reinforced Concrete Manholes

Precast reinforced concrete manholes shall be as specified on the drawings. Joints between precast concrete risers and tops shall be full-bedded in cement mortar and shall be smoothed to a uniform surface on both interior and exterior of the structure.

2.3.7 Frame and Cover for Gratings

Frame and cover for gratings shall be specified on the drawings. Weight, shape, size, and waterway openings for grates and curb inlets shall be as indicated on the plans.

2.3.8 Joints

2.3.8.4 PVC Plastic Pipes

Joints shall be solvent cement or elastomeric gasket type in accordance with the specification for the pipe and as recommended by the pipe manufacturer.

2.4 STEEL LADDER

Steel ladder shall be provided where the depth of the storm drainage structure exceeds 3.66 m(12 feet). These ladders shall be not less than 406 mm(16 inches) in width, with 19 mm(3/4 inch) diameter rungs spaced 305 mm(12 inches) apart. The two stringers shall be a minimum 10 mm(3/8 inch) thick and 63 mm(2-1/2 inches) wide. Ladders and inserts shall be galvanized after fabrication in conformance with [ASTM A 123/A 123M](#).

2.6 RESILIENT CONNECTORS

Flexible, watertight connectors used for connecting pipe to manholes and inlets shall conform to [ASTM C 923M](#)([ASTM C 923](#)).

2.7 HYDROSTATIC TEST ON WATERTIGHT JOINTS

2.7.1 Concrete, Clay, PVC and PE Pipe

A hydrostatic test shall be made on the watertight joint types as proposed. Only one sample joint of each type needs testing; however, if the sample joint fails because of faulty design or workmanship, an additional sample joint may be tested. During the test period, gaskets or other jointing material shall be protected from extreme temperatures which might adversely affect the performance of such materials. Performance requirements for joints in reinforced and nonreinforced concrete pipe shall conform to [AASHTO M 198](#) or [ASTM C 443M](#)([ASTM C 443](#)). Test requirements for joints in clay pipe shall conform to [ASTM C 425](#). Test requirements for joints in PVC and PE plastic pipe shall conform to [ASTM D 3212](#).

PART 3 EXECUTION

3.1 EXCAVATION FOR PIPE CULVERTS, STORM DRAINS, AND DRAINAGE STRUCTURES

Excavation of trenches, and for appurtenances and backfilling for culverts and storm drains, shall be in accordance with the applicable portions of SECTION 31 00 00 EARTHWORK for Utilities and the requirements specified below.

3.1.1 Trenching

The width of trenches at any point below the top of the pipe shall be as specified on the drawings. Sheet piling and bracing, where required, shall be placed within the trench width as specified. Contractor shall not overexcavate. Where trench widths are exceeded, redesign with a resultant increase in cost of stronger pipe or special installation procedures will be necessary. Cost of this redesign and increased cost of pipe or installation shall be borne by the Contractor without additional cost to the Government.

3.1.2 Removal of Rock

Rock in either ledge or boulder formation shall be replaced with suitable materials to provide a compacted earth cushion having a thickness between unremoved rock and the pipe of at least 200 mm(8 inches) or 13 mm(1/2 inch) for each meter(foot) of fill over the top of the pipe, whichever is greater, but not more than three-fourths the nominal diameter of the pipe. Where bell-and-spigot pipe is used, the cushion shall be maintained under the bell as well as under the straight portion of the pipe.

3.1.3 Removal of Unstable Material

Where wet or otherwise unstable soil incapable of properly supporting the pipe, as determined by the Contracting Officer, is unexpectedly encountered in the bottom of a trench, such material shall be removed to the depth required and replaced to the proper grade with select granular material and compacted. When removal of unstable material is due to the fault or neglect of the Contractor while performing shoring and sheeting, water removal, or other specified requirements, such removal and replacement shall be performed at no additional cost to the Government.

3.2 BEDDING

The bedding surface for the pipe shall provide a firm foundation of uniform density throughout the entire length of the pipe.

3.2.5 Plastic Pipe

Bedding for PVC and PE pipe shall meet the requirements of [ASTM D 2321](#). Bedding, haunching, and initial backfill shall be either Class IB or II material.

3.3 PLACING PIPE

Each pipe shall be thoroughly examined before being laid; defective or damaged pipe shall not be used. Plastic pipe shall be protected from exposure to direct sunlight prior to laying, if necessary to maintain adequate pipe stiffness and meet installation deflection requirements. Pipelines shall be laid to the grades and alignment indicated. Proper facilities shall be provided for lowering sections of pipe into trenches. Lifting lugs in vertically elongated metal pipe shall be placed in the same vertical plane as the major axis of the pipe. Pipe shall not be laid in water, and pipe shall not be laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches during construction shall be provided as necessary. Deflection of installed flexible pipe shall not exceed the following limits:

TYPE OF PIPE	MAXIMUM ALLOWABLE DEFLECTION (%)
Plastic	7.5

Not less than 30 days after the completion of backfilling, the Government may perform a deflection test on the entire length of installed flexible pipe using a mandrel or other suitable device. Installed flexible pipe showing deflections greater than those indicated above shall be retested by a run from the opposite direction. If the retest also fails, the suspect pipe shall be replaced.

3.3.1 PVC Pipe

Laying shall proceed upgrade with spigot ends of bell-and-spigot pipe and tongue ends of tongue-and-groove pipe pointing in the direction of the flow.

3.3.7 Multiple Culverts

Where multiple lines of pipe are installed, adjacent sides of pipe shall be at least half the nominal pipe diameter or 1 meter(3 feet) apart, whichever is less.

3.3.8 Jacking Pipe Through Fills

Methods of operation and installation for jacking pipe through fills shall conform to requirements specified in Volume 1, Chapter 1, Part 4 of [AREMA Eng Man](#).

3.5 DRAINAGE STRUCTURES

3.5.1 Manholes and Inlets

Construction shall be as specified on the drawings; complete with frames and covers or gratings; and with fixed galvanized steel ladders where indicated. Pipe studs and junction chambers of prefabricated corrugated metal manholes shall be fully bituminous-coated and paved when the connecting branch lines are so treated. Pipe connections to concrete manholes and inlets shall be made with flexible, watertight connectors.

3.6 STEEL LADDER INSTALLATION

Ladder shall be adequately anchored to the wall by means of steel inserts spaced not more than 1.83 m(6 feet) vertically, and shall be installed to provide at least 152 mm(6 inches) of space between the wall and the rungs. The wall along the line of the ladder shall be vertical for its entire length.

3.7 BACKFILLING

3.7.1 Backfilling Pipe in Trenches

After the pipe has been properly bedded, selected material from excavation or borrow, at a moisture content that will facilitate compaction, shall be placed along both sides of pipe in layers not exceeding 150 mm(6 inches) in compacted depth. The backfill shall be brought up evenly on both sides of pipe for the full length of pipe. The fill shall be thoroughly compacted under the haunches of the pipe. Each layer shall be thoroughly compacted with mechanical tampers or rammers. This method of filling and compacting shall continue until the fill has reached an elevation of at least 300 mm(12 inches) above the top of the pipe. The remainder of the trench shall be backfilled and compacted by spreading and rolling or compacted by mechanical rammers or tampers in layers not exceeding 8 inches. Tests for density shall be made as necessary to ensure conformance to the compaction requirements specified below. Where it is necessary, in the opinion of the Contracting Officer, that sheeting or portions of bracing used be left in place, the contract will be adjusted accordingly. Untreated sheeting shall not be left in place beneath structures or pavements.

3.7.3 Movement of Construction Machinery

When compacting by rolling or operating heavy equipment parallel with the pipe, displacement of or injury to the pipe shall be avoided. Movement of construction machinery over a culvert or storm drain at any stage of construction shall be at the Contractor's risk. Any damaged pipe shall be repaired or replaced.

3.7.4 Compaction

3.7.4.1 General Requirements

Cohesionless materials include gravels, gravel-sand mixtures, sands, and gravelly sands. Cohesive materials include clayey and silty gravels, gravel-silt mixtures, clayey and silty sands, sand-clay mixtures, clays, silts, and very fine sands. When results of compaction tests for moisture-density relations are recorded on graphs, cohesionless soils will show straight lines or reverse-shaped moisture-density curves, and cohesive soils will show normal moisture-density curves. Compaction shall be performed in accordance with SECTION 31 00 00 EARTHWORK for Utilities.

3.7.4.2 Minimum Density

Backfill over and around the pipe and backfill around and adjacent to drainage structures shall be compacted at the approved moisture content to the following applicable minimum density, which will be determined as specified below.

- a. Under airfield and heliport pavements, paved roads, streets, parking areas, and similar-use pavements including adjacent shoulder areas, the density shall be not less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material, up to the elevation where requirements for pavement subgrade materials and compaction shall control.
- b. Under unpaved or turfed traffic areas, density shall not be less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material.
- c. Under nontraffic areas, density shall be not less than that of the surrounding material.

3.7.5 Determination of Density

Testing shall be the responsibility of the Contractor and performed at no additional cost to the Government. Testing shall be performed by an approved commercial testing laboratory or by the Contractor subject to approval. Tests shall be performed in sufficient number to ensure that specified density is being obtained. Laboratory tests for moisture-density relations shall be made in accordance with ASTM D 1557 except that mechanical tampers may be used provided the results are correlated with those obtained with the specified hand tamper. Field density tests shall be determined in accordance with ASTM D 2167 or ASTM D 6938. When ASTM D 6938 is used, the calibration curves shall be checked and adjusted, if necessary, using the sand cone method as described in paragraph Calibration of the referenced publications. ASTM D 6938 results in a wet unit weight of soil and ASTM D 6938 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall be checked along with density calibration checks as described in ASTM D 6938. Test results shall be furnished the Contracting Officer. The calibration checks of both the density and moisture gauges shall be made at the beginning of a job on each different type of material encountered and at intervals as directed.

3.8 PIPELINE TESTING

3.8.1 Leakage Tests

Lines shall be tested for leakage by low pressure air or water testing or exfiltration tests, as appropriate. Low pressure air testing for vitrified clay pipes shall conform to ASTM C 828. Low pressure air testing for concrete pipes shall conform to ASTM C 924M(ASTM C 924). Low pressure air testing for plastic pipe shall conform to ASTM F 1417. Low pressure air testing procedures for other pipe materials shall use the pressures and testing times prescribed in ASTM C 828 or ASTM C 924M(ASTM C 924), after consultation with the pipe manufacturer. Testing of individual joints for leakage by low pressure air or water shall conform to ASTM C 1103M(ASTM C 1103). Prior to exfiltration tests, the trench shall be backfilled up to at least the lower half of the pipe. If required, sufficient additional backfill shall be placed to prevent pipe movement during testing, leaving the joints uncovered to permit inspection. Visible leaks encountered shall be corrected regardless of leakage test results. When the water table is 600 mm(2 feet) or more above the top of the pipe at the upper end of the pipeline section to be tested, infiltration shall be measured using a suitable weir or other device acceptable to the Contracting Officer. An exfiltration test shall be made by filling the line to be tested with water so that a head of at least 600 mm(2 feet) is provided above both the water table and the top of the pipe at the upper end of the pipeline to be tested. The filled line shall be allowed to stand until the pipe has reached its maximum absorption, but not less than 4 hours. After absorption, the head shall be reestablished. The amount of water required to maintain this water level during a 2-hour test period shall be measured. Leakage as measured by the exfiltration test shall not exceed 0.2 gallons per inch in diameter per 100 feet of pipeline per hour. When leakage exceeds the maximum amount specified, satisfactory correction shall be made and retesting accomplished.

3.8.2 Deflection Testing

Perform a deflection test on entire length of installed plastic pipeline on completion of work adjacent to and over the pipeline, including leakage tests, backfilling, placement of fill, grading, paving, concreting, and any other superimposed loads. Deflection of pipe in the installed pipeline under external loads shall not exceed 4.5 percent of the average inside diameter of pipe. Determine whether the allowable deflection has been exceeded by use of a pull-through device or a deflection measuring device.

a. Pull-through device: This device shall be a spherical, spheroidal, or elliptical ball, a cylinder, or circular sections fused to a common shaft. Circular sections shall be so spaced on the shaft that distance from external faces of front and back sections will equal or exceed diameter of the circular section. Pull-through device may also be of a design promulgated by the Uni-Bell Plastic Pipe Association, provided that the device meets the applicable requirements specified in this paragraph, including those for diameter of the device. Ball, cylinder, or circular sections shall conform to the following:

- 1 A diameter, or minor diameter as applicable, of 95 percent of the average inside diameter of the pipe; tolerance of plus 0.5 percent will be permitted.

2 A homogeneous material throughout, with a density greater than 1.0 as related to water at 4 degrees C(39.2 degrees F), and a surface Brinell hardness of not less than 150.

3 Center bored and through bolted with a 6 mm(1/4 inch) minimum diameter steel shaft having a yield strength of not less than 483 MPa(70,000 psi), with eyes or loops at each end for attaching pulling cables.

4 Each eye or loop shall be suitably backed with a flange or heavy washer such that a pull exerted on opposite end of shaft will produce compression throughout remote end.

b. Deflection measuring device: Sensitive to 1.0 percent of the diameter of the pipe being tested and accurate to 1.0 percent of the indicated dimension. Deflection measuring device shall be approved by the Contracting Officer prior to use.

c. Pull-through device: Pass the pull-through device through each run of pipe, either by pulling it through or flushing it through with water. If the device fails to pass freely through a pipe run, replace pipe which has the excessive deflection and completely retest in same manner and under same conditions as specified.

d. Deflection measuring device procedure: Measure deflections through each run of installed pipe. If deflection readings in excess of 4.5 percent of average inside diameter of pipe are obtained, retest pipe by a run from the opposite direction. If retest continues to show a deflection in excess of 4.5 percent of average inside diameter of pipe, remove pipe which has excessive deflection, replace with new pipe, and completely retest in same manner and under same conditions.

e. Warranty period test: Pipe found to have a deflection of greater than 5 percent of average inside diameter when deflection test is performed just prior to end of one-year warranty period shall be replaced with new pipe and tested as specified for leakage and deflection.